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CALIBRATION FACTORS FOR THE USE OF THE NCB CONE INDENTOR IN THE SYDNEY COALFIELD

P. Cain
Cape Breton Coal Research Laboratory

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CALIBRATION FACTORS FOR THE USE OF THE NCB CONE INDENTOR IN THE SYDNEY COALFIELD

by

P. Cain*

ABSTRACT

The National Coal Board (now British Coal) cone indentor is a portable instrument used in the United Kingdom for the rapid determination of compressive strength and cuttability of coal mine strata.

After a unit was obtained by the Cape Breton Development Corporation (CBDC) for use in the Sydney Coalfield collieries, the calibration factor relating cone indentor readings to rock strength and cuttability quoted in the instrument handbook were found to give results in which little confidence could be placed.

This report describes briefly a testing programme undertaken to relate indentor results to the compressive strength of strata from the Sydney Coalfield, and then gives details of the calibration factors derived.

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*Research Scientist, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

FACTEURS D'ÉTALONNAGE LORS DE L'UTILISATION DU POINÇON CONIQUE DU NCB À LA HOUILLÈRE DE SYDNEY

par

P. Cain*

RÉSUMÉ

Le poinçon conique du National Coal Board (maintenant appelé British Coal) est un instrument portatif utilisé dans le Royaume-Uni pour déterminer rapidement la résistance à la compression et la capacité d'abattage des couches dans les mines de charbon.

La Société de développement du Cap-Breton a obtenu un tel poinçon afin de l'utiliser dans le gîte de Sydney. Lors des essais, on a trouvé que les facteurs d'étalonnage reliant les données obtenues à l'aide du poinçon conique à celles de la résistance du roc et de la capacité d'abattage indiquées dans le manuel d'instructions de l'instrument, donnaient des résultats sur lesquels on ne pouvait compter.

Le présent rapport décrit brièvement un programme d'essais réalisé à la houillère Sydney dans le but de relier les résultats obtenus à l'aide du poinçon à ceux de la résistance à la compression des couches du gîte de Sydney, et enfin de donner les détails des facteurs d'étalonnage qui ont été dérivés de ces résultats.

*Chercheur scientifique, Laboratoire de recherche sur le charbon du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources, Canada, Sydney.

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INTRODUCTION

The NCB cone indentor is a hand-held portable instrument capable of determining an index of hardness of rock specimens in the field. The index of hardness has been shown to be directly correlatable with a number of standard rock properties, notably uniaxial compressive strength and cuttability (Szlavin, 1974).

The unit consists of a portal steel frame 175 mm long in which a steel strip is clamped along a longitudinal axis. In the middle of one longitudinal side of the frame a dial gauge is inserted in such a way that its probe is in contact with one side of the steel strip. In the middle of the opposite side of the frame is fitted a micrometer. The micrometer has a hollow spindle into which slides a tungsten carbide cylinder with a conical (40°) tip. The carbide point is free to rotate in the hollow spindle. The micrometer measures the indentation of the sample and the dial gauge measures the amount of deflection of the spring.

Complete directions for the use of the indentor are given elsewhere (NCB, 1977). Briefly, the indentor must be calibrated so that the deflection of the spring (D_1) under a force of 40 N is known. The specimen, in the form of a rock chip, is lightly clamped into the instrument. The dial gauge is set to zero and the micrometer reading, M_0, is noted. The carbide cone is then advanced until the dial gauge reading equals D_1, at which point the micrometer is read again (M_1).

The cone indentor index, I, represents the degree of penetration of the sample (P) by the carbide point at a standard force, represented by the spring deflection, D_1 (Equation 1). In this way it is similar to the metallurgical determination of hardness.

$$I = D/P \qquad \text{Eq. 1}$$

where $$P = (M_1 - M_0) - D_1$$

The cone indentor index, used with a correction factor of 24.8 (Szlavin, 1974) has been found to give a good indication of the compressive strength of rock. Its use in the Sydney Coalfield, however, gave rise to concern (Forgeron, 1984). The use of the suggested correction factor on indices derived for samples from the local rocks (MacDonald, 1983) gave

spurious results. A testing programme was begun to develop a more accurate calibration factor for local use.

LABORATORY TESTING PROGRAMME

The testing was contracted out by the CANMET Coal Research Laboratory (CBCRL) in Sydney, Nova Scotia to the University College of Cape Breton (UCCB). Samples for the testing programme were provided by the Cape Breton Development Corporation (CBDC) in the form of core samples.

Staff at the UCCB classified the samples according to lithology and prepared them (to American Society for Testing and Materials standards) for uniaxial compression testing. Most of the core samples were 45-40 mm in diameter, and every effort was made to obtain samples for testing that had a height:width ratio of 2:1. When this was not possible, correction equations were used (NCB, 1977) to determine approximate equivalents. No corrections were made for differences in the core diameters.

After testing the intact cores and recording the uniaxial compressive strength, the off-cut end pieces left over from the core preparation and the remnants of the tested samples were then crushed using a hammer and bucking board and bagged separately. These rock chips were then index tested using the cone indentor.

RESULTS

Standard cone indentor values (corresponding to a sample loading of 40 N) were determined from 50 (in some cases only 30) individual readings from each sample. At first, values for both the off-cut samples and the residual test material were obtained; it was thought that compression testing of the samples might reduce the cone indentor index obtained from the tested samples due to the introduction of microcracks. The hypothesis was rejected after statistical examination of the results proved that there was no correlation between the test history and the indentor index (CANMET, 1985).

The reduced results for the core samples are given in Table 1. Both mean and median values of the cone indentor index are given. The grain

Table 1 - Results of cone indentor and uniaxial compressive strength testing of Sydney Coalfield strata

Rock Type	Grain Size (mm)	Core Dia. (mm)	Uniaxial Compressive Strength (MPa)	Index Value (Mean)	Index Value (Median)
Sandstone (coarse)	.4	32.5	39.0	2.2649	2.2540
Sandstone (coarse)	.4	45.0	40.0	2.6131	2.5330
Sandstone (coarse)	.4	45.0	42.8	2.3136	2.2540
Sandstone (coarse)	.4	45.0	56.0	2.7608	2.5330
Sandstone (coarse)	.4	45.0	46.2	2.2414	2.1625
Sandstone (medium)	.2	48.0	60.0	2.5792	2.5350
Sandstone (medium)	.2	48.0	60.0	2.5898	2.4400
Sandstone (medium)	.2	48.0	71.5	2.8244	2.6440
Sandstone (medium)	.2	48.0	61.7	2.6488	2.5580
Sandstone (fine)	.075	45.0	79.7	2.7729	2.5090
Sandstone (fine)	.075	45.0	74.8	2.7622	2.8300
Sandstone (fine)	.075	45.0	83.5	2.8851	2.8005
Sandstone (fine)	.075	19.0	50.3	2.6988	2.7420
Sandstone (fine)	.075	55.0	72.5	2.9332	2.7420
Siltstone	.025	19.0	94.0	3.3054	3.1670
Siltstone	.025	19.0	55.5	2.6515	2.5580
Siltstone	.025	19.0	59.4	3.0971	2.8725
Siltstone	.025	48.0	103.0	2.8288	2.6340
Siltstone	.025	48.0	33.9	2.1107	2.1180
Siltstone (*)	.025	37.0	35.9	1.9113	1.8700
Mudstone	.005	36.5	25.7	1.8026	1.7500
Mudstone	.005	45.0	31.8	1.8127	1.6945
Mudstone	.005	45.0	25.7	1.8716	1.7270
Mudstone	.005	45.0	33.3	1.8484	1.7500
Mudstone	.005	45.0	33.7	1.3576	1.3105
Mudstone	.005	45.0	33.9	1.8829	1.7730
Mudstone	.005	44.5	33.5	1.9418	1.8470

*Indicates sample value obtained from MacDonald, 1983.

sizes shown for the different rock types were obtained from microscopic analysis of the samples. The actual values given represent the mid-range of the grain sizes observed.

By dividing the uniaxial compressive strength by the cone indentor index for each sample, the individual correction factors can be determined. These have been plotted against the logarithm of the grain size in Figure 1. The resulting graph clearly shows that there is a variation of the correction factor with the grain size. The median value of the correction factor from each type of samples gives a slightly higher factor, which is recommended on the basis that the mean value is likely to be adversely affected by spuriously high index values.

CONCLUSIONS

The testing programme outlined above determined not only that the published correction factor generally overestimated the strength of the material thus derived, but also that a range of correction factors should be used depending on the grain size of the rock being tested. The median factors to be used for each rock type are as follows:

Coarse Sandstone	19.11
Medium Sandstone	24.86
Fine Sandstone	26.56
Siltstone	22.02
Mudstone	18.62

The use of these factors should give a much better approximation of the uniaxial compressive strength, and improve confidence in the use of the cone indentor within the coalfield.

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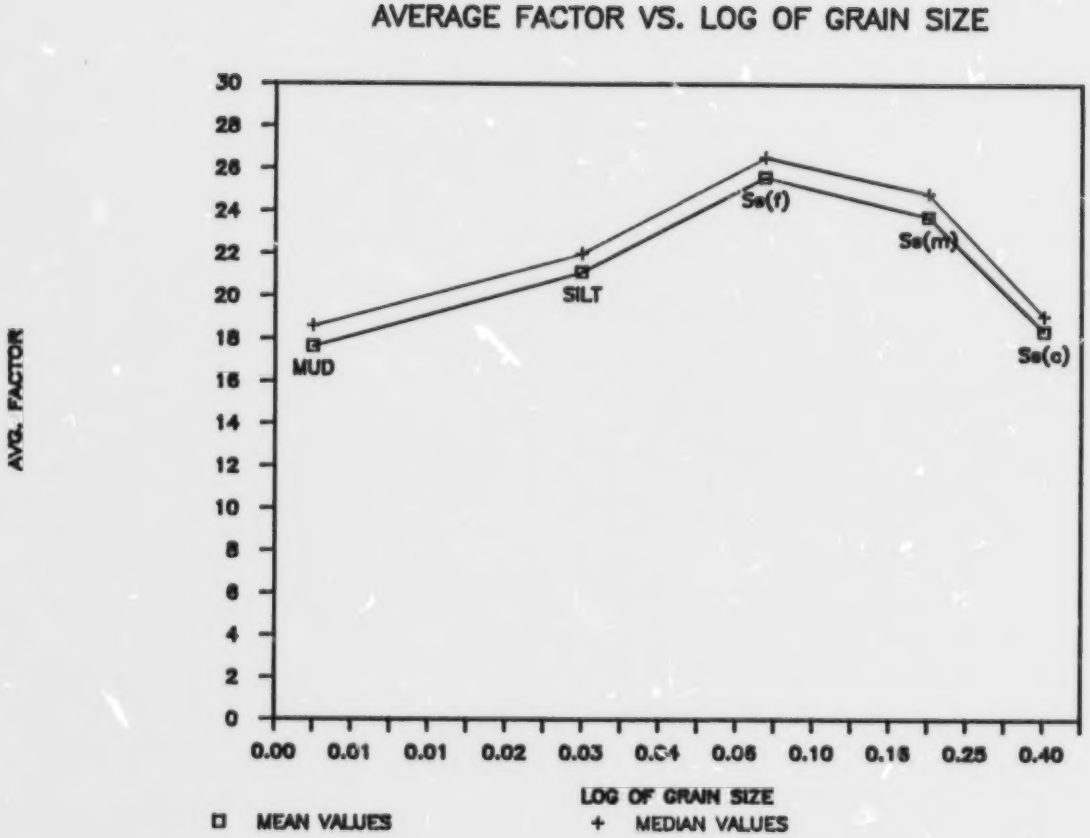

Figure 1 - Relationship between correction factor and specimen grain size

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